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COMPARATIVE VERIFICATION OF GUIDANCE, LOCAL, AND PERSISTENCE FORECASTS OF CEILING AND VISIBILITY--NO. 1

Richard Crisci, George Hollenbaugh and
David J. Vercelli

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We recently computed verification scores for TDL's automated MOS forecasts of ceiling and visibility for the period April through September 1975. These guidance forecasts were generated from the warm season (April-September) equations described in National Weather Service (NWS) Technical Procedures Bulletin No. 120 (NWS, 1974). Of the 233 terminals for which we issue guidance forecasts twice each day, 94 were selected for this verification; they're shown in Table 1.

We also computed verification scores for ceiling and visibility forecasts made by NWS forecasters at Weather Service Forecast Offices (WSFO's) responsible for official terminal forecasts (FT's) for the same 94 terminals shown in Table 1. These local forecasts were supplied to us by the Technical Procedures Branch of the NWS Office of Meteorology and Oceanography in conjunction with the NWS combined aviation/public weather verification system (NWS, 1973).

Finally, we also computed verification scores for persistence forecasts of ceiling and visibility, again for the identical group of 94 terminals.

Table 1. 94 terminals used for comparative verification of ceiling and visibility forecasts.

BKW	BECKLEY, W. VA.	TCC	TUCUMCARI, N. MEX.
RDU	RALEIGH-DURHAM, NC.	MKC	KANSAS CITY, MO.
ORF	NORFOLK, VA.	DDC	DODGE CITY, KAN.
PHL	PHILADELPHIA, PA.	STL	ST LOUIS, MO.
DCA	WASHINGTON, D.C.	TOP	TOPEKA, KAN.
CRW	CHARLESTON, W. VA.	MSN	MADISON, WIS.
GSP	GREENVILLE, S.C.	MKE	MILWAUKEE, WIS.
CLT	CHARLOTTE, N.C.	SSM	SAULT ST. MARIE, MICH.
CAE	COLUMBIA, S.C.	SBN	SOUTH BEND, IND.
BUF	BUFFALO, N.Y.	FAR	FARGO, N. DAK.
ALB	ALBANY, N.Y.	INL	INTL. FALLS, MINN.
ACY	ATLANTIC CITY, N.J.	MSP	MINNEAPOLIS, MINN.
BOS	BOSTON, MASS.	BRL	BURLINGTON, IOWA
EWR	NEWARK, N.J.	DSM	DES MOINES, IOWA
BTV	BURLINGTON, VT.	OMA	OMAHA, NEB.
CON	CONCORD, N.H.	FSD	SIOUX FALLS, S. DAK.
PWM	PORTLAND, ME.	DEN	DENVER, COLO.
PVD	PROVIDENCE, R.I.	GJT	GRAND JUNCTION, COLO.
SYR	SYRACUSE, N.Y.	BIS	BISMARCK, N. DAK.
CLE	CLEVELAND, OHIO	CYS	CHEYENNE, WYO.
CMH	COLUMBUS, OHIO	BFF	SCOTTSBLUFF, NEB.
ERI	ERIE, PA.	SHR	SHERIDAN, WYO.
JFK	NEW YORK, N.Y.	RAP	RAPID CITY, S. DAK.

PIT	PITTSBURGH, PA.
SAV	SAVANNAH, GA.
DFW	FORT WORTH, TEX.
JAN	JACKSON, MISS.
MIA	MIAMI, FLA.
MSY	NEW ORLEANS, LA.
SAT	SAN ANTONIO, TEX.
HOU	HOUSTON, TEX.
MEI	MERIDIAN, MISS.
ATL	ATLANTA, GA.
BHM	BIRMINGHAM, ALA.
JAX	JACKSONVILLE, FLA.
TYS	KNOXVILLE, TENN.
MEM	MEMPHIS, TENN.
MOB	MOBILE, ALA.
SHV	SHREVEPORT, LA.
ABI	ABILENE, TEX.
LIT	LITTLE ROCK, ARK.
FSM	FORT SMITH, ARK.
OKC	OKLAHOMA CITY, OKLA.
TUL	TULSA, OKLA.
LBB	LUBBOCK, TEX.
ELP	EL PASO, TEX.
ABQ	ALBUQUERQUE, N. MEX.
IND	INDIANAPOLIS, IND.
LEX	LEXINGTON, KY.
SDF	LOUISVILLE, KY.
SPI	SPRINGFIELD, ILL.
ORD	CHICAGO, ILL.
DTW	DETROIT, MICH.
FLG	FLAGSTAFF, ARIZ.
LAX	LOS ANGELES, CAL.
PHX	PHOENIX, ARIZ.
RNO	RENO, NEV.
SAN	SAN DIEGO, CAL.
SFO	SAN FRANCISCO, CAL.
SLC	SALT LAKE CITY, UTAH
BOI	BOISE, IDAHO
GTF	GREAT FALLS, MONT.
MSO	MISSOULA, MONT.
PDT	PENDLETON, ORE.
PIH	POCATELLO, IDAHO
GEG	SPOKANE, WASH.
PDX	PORTLAND, ORE.
SEA	SEATTLE-TACOMA, WASH.
FAT	FRESNO, CALIF.
CDC	CEDAR CITY, UTAH
LAS	LAS VEGAS, NEV.

Our guidance forecasts are expressed as the probability of each of 5 categories for both ceiling and visibility; the category definitions are shown in Table 2. The probability forecasts are transformed into a categorical forecast and presented as the "best category" in the forecast message. The transformation is made such that the verification score for the NWS scoring matrix (NWS, 1973) is maximized. For comparative verification, we used this categorical forecast since the local and persistence forecasts are for specific values of ceiling and visibility, which can be assigned to a category for direct comparison.

Table 2. Ceiling and visibility categories used for MOS 5-category forecasts.

Category	Ceiling (ft)	Visibility (mi)
1	$\leq$ 100	$\leq$ 3/8
2	200-400	1/2-7/8
3	500-900	1-2 1/2
4	1000-1900	3-4
5	$\geq$ 2000	$\geq$ 5

Our MOS system generates ceiling and visibility guidance forecasts for projections of 12, 18, 24 and 30 hours from the numerical model runs at both 0000 GMT and 1200 GMT; we've computed verification statistics for the first three projections. FT's are expressed in a form which covers all hours of the 24-hour period for which they are valid; officially, they're verified at 12, 15, and 21 hours after 0000 GMT or 1200 GMT. Therefore, direct comparison between the guidance and local forecasts was possible only at the 12-hour projection. Persistence forecasts were determined from the last surface airways observation available to the local forecaster before the FT filing deadline--the ceiling and visibility values which existed in that observation were used for each verification time that followed.

For all the forecasts involved in this comparative verification, we constructed contingency tables which were then used to compute several different verification scores; bias by category (the number of forecasts of a given category divided by the number of observations of that category), percent correct, and the NWS matrix score. We have summarized the scores in Tables 3 through 6; each table covers one element for one cycle time, for all forecast systems, arranged by projection. Although we are concerned primarily with evaluating our guidance forecasts in absolute terms and relative to local and persistence forecasts, we've also included statistics for the latter two systems for verification times at which guidance forecasts are not available.

Examining the tables, we find that local and persistence forecasts outscored our guidance forecasts overall for 12-hour projections. This result is not surprising since persistence and local forecasters have a decided advantage over the MOS system for the first projection. The observation used for the persistence "forecast" occurs two to three hours (depending on the cycle and region) before the first verification time; this is also the last observation seen by the local forecaster prior to the FT filing deadline. Virtually all the MOS equations for ceiling and visibility contain surface observation predictors; the data required to generate a forecast come from observations taken six hours before verification time. Thus, the so-called 12-hour projection is in reality only a two or three hour projection for persistence and local forecasters, and a six hour projection for the MOS system. Note that the scores for persistence are consistently better than those for the local forecasts, which emphasizes the difficulty of beating persistence for short-range projections.

For the 18-hour projection, our guidance forecasts did as well or better than persistence for both percent correct and NWS matrix score. The scores for bias, however, reveal that the MOS system significantly underforecast the lower four categories--particularly the lowest three--for both elements in both cycles, while persistence displayed less bias than our guidance forecasts in the 1200 GMT cycle but greatly overforecast the lower categories in the 0000 GMT cycle. The radically different bias scores for persistence are due to the fact that in the 0000 GMT cycle an early morning observation--when ceilings and visibilities are climatologically at their lowest--becomes the forecast for a verification time which normally has a high frequency of category 5 occurrences. Conversely, the persistence forecast in the 1200 GMT cycle depends on an afternoon observation which, in the warm season, has a very high likelihood of containing a category 5 ceiling and visibility. Thus, at 0600 GMT, when the "18-hour" forecast is verified—a time which also displays a relatively high frequency of category 5 conditions—persistence is apt to be a good forecast and the verification scores bear this out.

Scores for the 24-hour projection show a pattern similar to those for the 18-hour projection: persistence greatly overforecast the lower categories in the 0000 GMT cycle and, consequently, its PC and MS scores are markedly inferior compared to our guidance forecasts; in the 1200 GMT cycle, bias scores for persistence indicate a strong tendency to underforecast the lower categories and, like those for the MOS system, PC and MS scores suffered. In fact, PC scores for persistence are better than those for the MOS system in the 1200 GMT cycle. However, our guidance forecasts scored better than persistence for MS.

A few words need to be said about the performance of our MOS system guidance forecasts with respect to bias. In general, our guidance forecast system seriously underforecasts the lower categories, especially the lowest two or three. Since those lower categories are of major importance to aviation interests, our product is not fully satisfying the needs of our users. We have been aware of this problem for some time, and we've experimented with threshold probabilities in an attempt to improve the bias characteristics (Crisci, 1976). We're currently in the midst of developing a new system of prediction equations for ceiling and visibility guidance forecasts, and we expect to derive threshold probabilities for these new equations in order to alleviate our past shortcomings in terms of bias.

REFERENCES

Crisci, Richard L., 1976: Improving the bias in MOS ceiling and visibility forecasts. TDL Office Note No. 76-4, Techniques Development Laboratory, Silver Spring, Md., 8 pp.

National Weather Service, 1973: Combined aviation/public weather forecast verification. Operations Manual Chapter C-73, 14 pp.

National Weather Service, 1974: The use of model output statistics for predicting ceiling and visibility. Technical Procedures Bulletin No. 120, 10 pp.

Table 3. Comparative verification of persistence, MOS guidance, and local ceiling forecasts, 0000 GMT cycle, for the period April-September 1975, for 94 stations. PC is percent correct, MS is NWS matrix score.

Projection (Hr)	Type	Bias by Category					PC	MS
		1	2	3	4	5		
12	MOS Guidance	.16	.80	.53	1.12	1.04	84.6	65.0
	Persistence	.77	.79	.82	.85	1.03	88.0	66.7
	Local	.39	.80	.76	1.21	1.02	87.0	66.5
15	Local	.43	.40	.49	.82	1.06	84.9	66.0
	Persistence	5.46	1.46	.85	.53	1.04	83.6	65.3
18	MOS Guidance	.00	.04	.34	.79	1.04	90.7	67.5
	Persistence	19.17	3.58	1.83	.90	.96	85.8	65.5
21	Local	.40	.27	.29	.76	1.03	93.6	68.2
	Persistence	31.20	4.83	2.51	1.40	.93	85.8	65.0
24	MOS Guidance	.00	.04	.20	.44	1.04	94.2	68.0
	Persistence	7.44	3.15	2.59	1.64	.93	86.4	65.3

Table 4. Comparative verification of persistence, MOS guidance, and local visibility forecasts, 0000 GMT cycle, for the period April-September 1975, for 94 stations. PC is percent correct, MS is NWS matrix score.

Projection (Hr)	Type	Bias by Category					PC	MS
		1	2	3	4	5		
12	MOS Guidance	.20	.37	.61	.79	1.09	79.0	63.8
	Persistence	.75	.62	.41	.74	1.10	82.7	65.5
	Local	.47	.96	.47	1.45	1.02	80.0	65.3
15	Local	.43	.46	.30	1.06	1.03	86.5	66.5
	Persistence	5.31	1.75	.84	.99	.99	83.9	65.3
18	MOS Guidance	.00	.05	.09	.26	1.06	92.4	67.8
	Persistence	16.30	5.26	1.58	1.45	.94	85.6	65.6
21	Local	.56	.15	.16	.60	1.04	92.9	68.0
	Persistence	20.89	4.15	1.89	1.69	.93	85.4	65.4
24	MOS Guidance	.00	.00	.04	.28	1.06	93.1	67.8
	Persistence	11.29	3.43	1.57	1.78	.94	85.6	65.5

Table 5. Comparative verification of persistence, MOS guidance, and local ceiling forecasts, 1200 GMT cycle, for the period April-September 1975, for 94 stations. PC is percent correct, MS is NWS matrix score.

Projection (Hr)	Type	Bias by Category					PC	MS
		1	2	3	4	5		
12	MOS Guidance	.57	.77	.96	1.06	1.00	93.5	68.2
	Persistence	.43	.56	1.06	1.09	1.00	95.3	68.9
	Local	.14	.49	.67	1.14	1.01	95.3	68.9
15	Local	.40	.43	.68	1.26	1.01	92.9	68.1
	Persistence	.24	.47	.75	.99	1.01	92.9	68.0
18	MOS Guidance	.00	.30	.53	.80	1.04	90.4	66.8
	Persistence	.08	.28	.59	.82	1.04	90.6	66.8
21	Local	.12	.39	.81	1.57	1.01	85.4	65.3
	Persistence	.05	.19	.41	.67	1.08	86.8	65.0
24	MOS Guidance	.01	.15	.48	1.00	1.08	83.2	63.8
	Persistence	.04	.13	.31	.53	1.12	83.8	63.4

Table 6. Comparative verification of persistence, MOS guidance, and local visibility forecasts, 1200 GMT cycle, for the period April-September 1975, for 94 stations. PC is percent correct, MS is NWS matrix score.

Projection (Hr)	Type	Bias by Category					PC	MS
		1	2	3	4	5		
12	MOS Guidance	.00	.23	.29	.85	1.03	92.6	68.0
	Persistence	.60	.88	.71	1.03	1.01	94.2	68.7
	Local	.60	.65	.31	1.17	1.01	93.7	68.5
15	Local	.48	1.41	.59	1.37	.99	91.7	68.1
	Persistence	.28	1.65	.96	.93	1.00	92.6	68.2
18	MOS Guidance	.01	.04	.19	.69	1.05	90.8	67.3
	Persistence	.08	.51	.66	.82	1.03	90.3	67.2
21	Local	.19	.68	1.05	1.72	.96	82.2	65.2
	Persistence	.04	.23	.49	.60	1.07	86.5	65.6
24	MOS Guidance	.00	.02	.46	1.50	1.04	74.3	62.4
	Persistence	.03	.16	.18	.43	1.19	78.2	62.1